Foraging Ecology and Occurrence of Opah (*LAMPRIS GUTTATUS)* in the Southern California Bight

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Introduction

The opah (Lampris guttatus) is a large, mid-water pelagic fish that is encountered worldwide from 70º N to 45º S. They are a highly valued food fish that can be purchased fresh or frozen at fish markets globally. In the northeast Pacific opah are found along the entire U.S. West Coast but are only caught occasionally in Washington and Oregon. "Small eye" opah occur seasonally in the Southern California Bight (SCB) and off the coast of Mexico. Here they are caught incidentally in both the California drift gillnet fishery (CADGN) that targets swordfish and by recreational fishermen targeting albacore, yellowfin, and bluefin tuna. Despite their value to commercial and recreational fishermen, opah have been largely ignored by fisheries biologists and little research on their biology, trophic ecology, or patterns in abundance has been conducted, especially in the SCB. It isn't clear how abundance may be impacted by environmental variability.

To begin to fill some of the data gaps, the Southwest Fisheries Science Center (SWFSC) has recently initiated a research program on opah. Genetic analysis conducted at Southwest Fisheries Science Center (SWFSC) confirmed two distinct species exist in the North Pacific which are characterized by the relative size of their eye. Currently there are no comprehensive diet studies for opah in the SCB, which is an important foraging ground for many commercially harvested fish as well as marine mammals, seabirds, and other fish (Pinkas et al. 1971). Thus it is unclear how they fit into the local foodweb and if their diets differ from opah in the central Pacific.

Objectives:
1) Characterize the prey of opah
2) Investigate inter-annual differences in catch rates of opah in the SCB with respect to ENSO events

Methods

Sample Collection

Opah were sampled in 2009 and 2010 during the annual SWFSC Juvenile Shark Abundance Survey. Opah were caught using commercial longline fishing gear. On average, 2 sets were conducted daily during the 30 day cruise. Sets consisted of 200 hooks baited with mackerel which were set over a 2 mile distance. Soak time was approximately 4 hours. Samples were collected from fish that suffered mortality including DNA, liver, heart, muscle, spines, scales, and stomachs. Analysis is preliminary and the focus has been on stomach contents.

Stomach Processing

Stomachs were frozen and stored before the contents were processed and transferred (Glaser, et al. 2009) into glass jars. Prey items were identified to the lowest possible taxonomic level. Whole or partial remains of teleosts and cephalopods were identified using either vertebrae, beaks, or otoliths (Clothier 1950). Individual prey were counted, weighed and preserved. Whole vertebral columns and the lower rostrum of beaks were measured to estimate the original weight of prey items using standard equations (Fishbase, Wolff 1984).

Data Analysis

Importance of different prey items was assessed using the Index of Relative Importance (IRI) (Pinkas et al. 1971). IRI was converted to a percentage.

IRI = (%N + %W)* %F
%N = total number of each taxa/ total number of all taxa
%W = total weight of each taxa/ total weight of all taxa
%F = total stomachs containing each taxa/ total stomachs

Data from the CADGN Fishery Observer Database (figure 1) and Commercial Passenger Fishing Vessel logbooks (figure 2) were used respectively to determine catch per set and total catch per year. Occurrence of opah in the SCB was investigated by comparing catch to fluctuations in the Oceanic Niño Index (http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml). Total fishing effort was not investigated.

Results

Table 1: Summary of opah caught with identifiable stomachs contents. Length values are reported as mean (standard deviation).

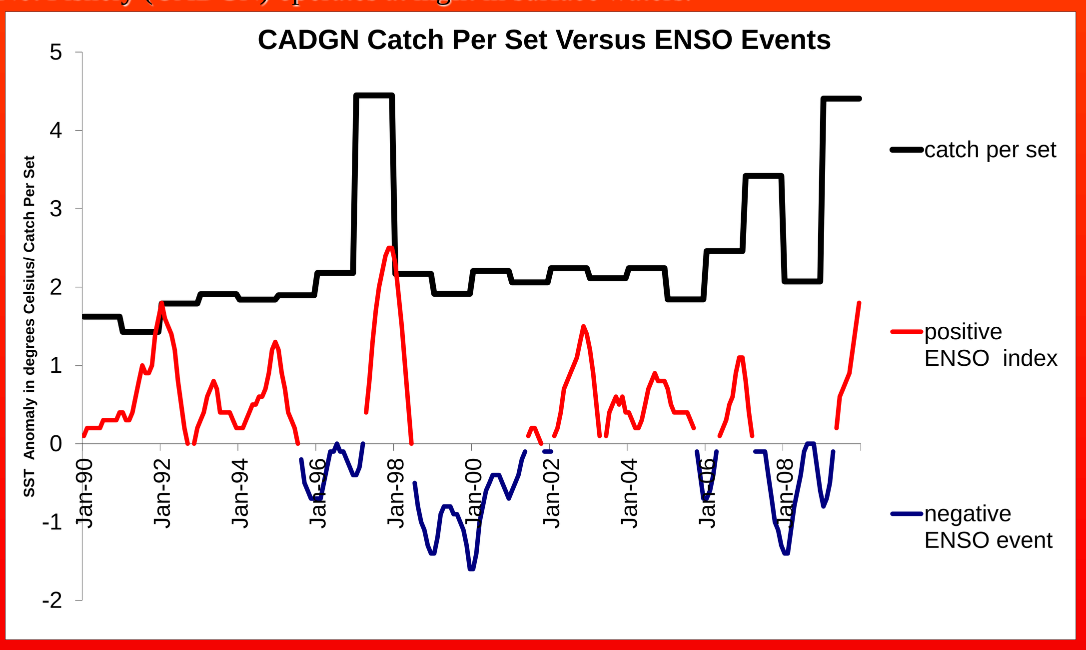
Year	Species	n	Length (cm)
2009	opah	1	98.5
2010	opah	9	103.2 (6.6)

Table 2: Summary of prey species results with %F, %N, %w, IRI, and %IRI. Sorted by %IRI from highest to lowest.

Taxa= prey spp	**%F**	**%N**	**%W**	**IRI**	**%IRI**
Loligo opalescens	90	0.317	0.157	42.65	38.41
Gonatus spp	60	0.198	0.322	31.21	28.1
Dosidicus gigas	30	0.081	0.328	12.28	11.06
unknown invert	100	0.067	2E-05	6.734	6.064
Octopodoteuthis spp	50	0.024	0.057	4.044	3.641
unknown fish	70	0.038	9E-06	2.651	2.388
Pleuronichthys decurrens	30	0.08	0.002	2.45	2.206
Octopus rubescens	50	0.039	0.004	2.147	1.934
Gonatopsis spp	30	0.02	0.028	1.42	1.279
Histioteuthis spp	20	0.01	0.048	1.158	1.043
Argonauta spp	40	0.01	0.008	0.704	0.634
Lestidiops ringens	20	0.035	9E-06	0.701	0.632
Vampyroteuthis infernalis	30	0.008	0.014	0.67	0.604
unknown algae	40	0.014	2E-04	0.567	0.511
unknown squid	40	0.007	0.004	0.44	0.396
Merluccius productus	30	0.01	2E-06	0.295	0.265
Magnisudis atlantica	10	0.006	0.02	0.254	0.229
Japatella spp	30	0.006	1E-06	0.168	0.152
Onychoteuthis spp	30	0.004	6E-04	0.144	0.129
Sebastes levis	10	0.011	3E-04	0.115	0.103
Cranchia scabra	10	0.003	0.008	0.106	0.096
Myctophid spp	20	0.004	1E-06	0.084	0.076
Sardinops sagax	10	0.001	3E-07	0.014	0.013
salp	10	0.001	3E-07	0.014	0.013
piece of lime	10	0.001	3E-07	0.014	0.013
rock	10	0.001	3E-07	0.014	0.013

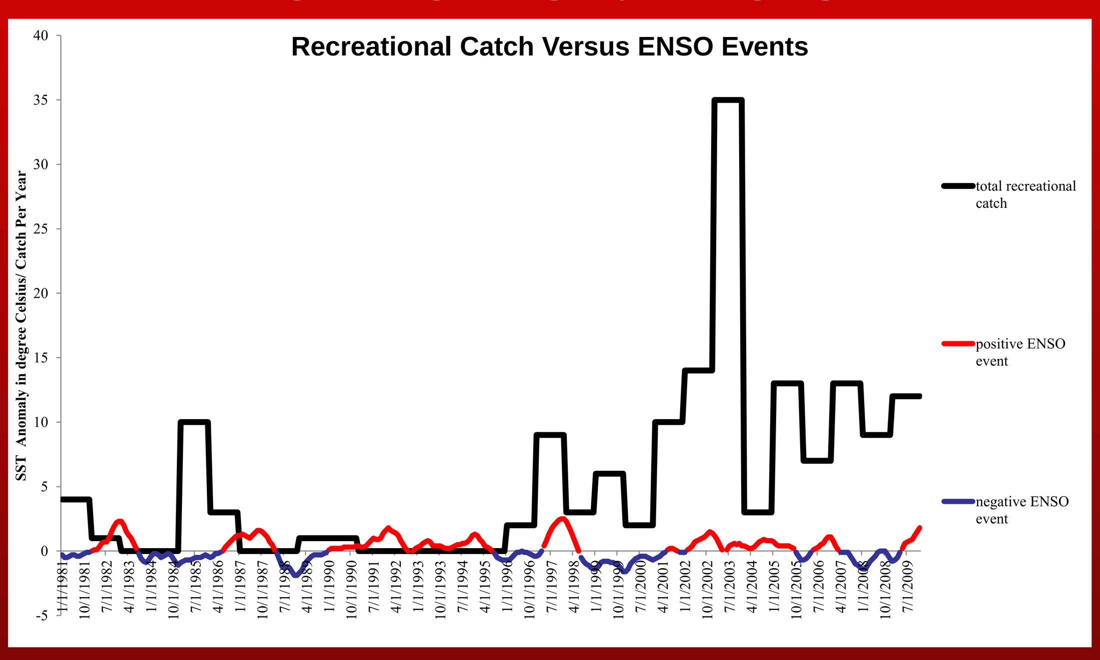
In the 10 opah a total of 19 species were identified with cephalopods making up 5 of the 7 most important prey species.

Figure 1: Catch per set compared to the Oceanic Niño Index. The California Drift Gill Net Fishery (CADGN) operates at night in surface waters.



Based on a preliminary analysis of the CADGN Fishery Observer Database, catch rates from 1990 to 2009 averaged 2.31 opah per set. Peak catch rates were observed during 1997 (4.44), 2007 (3.41), and 2009 (4.4). CPFV logbooks reported an average of 5.44 opah per year with peak catch occuring in 2003 with 35 opah.

Figure 2: Recreationally caught opah catch per year for the CPFV fleet compared to the Oceanic Niño Index. Opah are caught on single day or overnight trips.



Discussion

Opah in the SCB eat a range of fish and squid species that are associated with the mesopelagic waters indicating that opah are primarily foraging in the mid-water. A previous study conducted in the central North Pacific found that mesopelagic prey species dominated opah diet composition (Choy C.A. et al. 2009).

13 species of squid were found in opah stomachs with *Loligo opalescens* occurring in 90% of stomachs. A similar study on southern opah (*Lampris immaculatus*) found that opah preyed on only a few species of squid and fish, with one species of squid, *Moroteuthis ingens*, occurring in 93% of fish (Jackson G.D. et al. 2000).

Kelp was found in 30% of stomachs indicating opah may feed near floating kelp. One stomach contained curlefin sole and juvenile cowcod often associated with mud flats. This suggests that opah likely use the entire water column to forage and may be foraging in association with the benthos.

Observer data suggest that opah catch increases during positive ENSO events. This is similar to reports for the 1982-83 El Niño events when increases in opah landings were documented in the CADGN fishery (MacWilliams S.D., and Allen, 2001). Not all ENSO events see increases in catch. The relationship is not obvious in the CPFV logbook data.

In 2009 and 2010 combined, during the SWFSC's annual Juvenile Shark Abundance Survey, 24 opah were caught using longline gear baited with Pacific mackerel. In contrast, only one opah was caught in all of the 19 years of the survey prior to 2009. Analyses of the variability in survey catch as well as further examinations using all commercial and recreational catch data are underway.

Conclusions

- Based on the data collected to date, opah appear to be primarily feeding on species associated with the deep scattering layer (DSL). This is consistent with their diel migrations that are similar to those of swordfish that also feed on the DSL.
- Compared to data compiled at the SWFSC on albacore tuna, opah appear to eat a greater diversity of squid species. Although there is some species overlap with albacore tuna, opah diets share more in common with swordfish. Considering that opah are often caught in association with albacore, the differences in their diets could reflect habitat partitioning.
- Opah stomach content analysis could provided a cost effective means for characterizing differences in the occurrence of poorly studied mesopelagic species over short and long time scales. Opah may provide access to species from a realm that is still very unknown.
- Low recreational catch during the early 90's likely relates to differences in fishing effort and technology. Despite the fact that there are more people fishing today, and they are fishing with better gear and advanced electronics, opah may simply be increasing in availability to recreational anglers.
- While further analysis including changes to the CADGN fishery must be taken into account, the catch of opah in the SCB appears to be increasing. A more detailed examination of trophic overlap between opah and other local predators will help to identify whether the increase results from a relaxation of competition with a reduction in top predators, or whether some other factor is contributing to the increase.
- NEXT STEPS
  - Collect more sample from "small eye" opah in the SCB
  - Collect "big eye" opah samples from HI for comparison
  - Quantitative comparison with other local top predators
  - Isotope analysis in regards to trophic overlap
  - Further explore catch and effort data including the recreational private vessel catch to examine factors contributing to changes in local relative abundance

Acknowledgements: Kyle Newton (photo credit). Captain and crew of the Ventura II, and Southern Horizon. All the NOAA biologist involved sample collection. Antonella Preti, Mark Lowry and John Hyde for prey identification. and volunteers Kerston Mulenberg, and Jose Hurtado for help in the lab.